Experimental Investigation of an Inter Compressor Duct

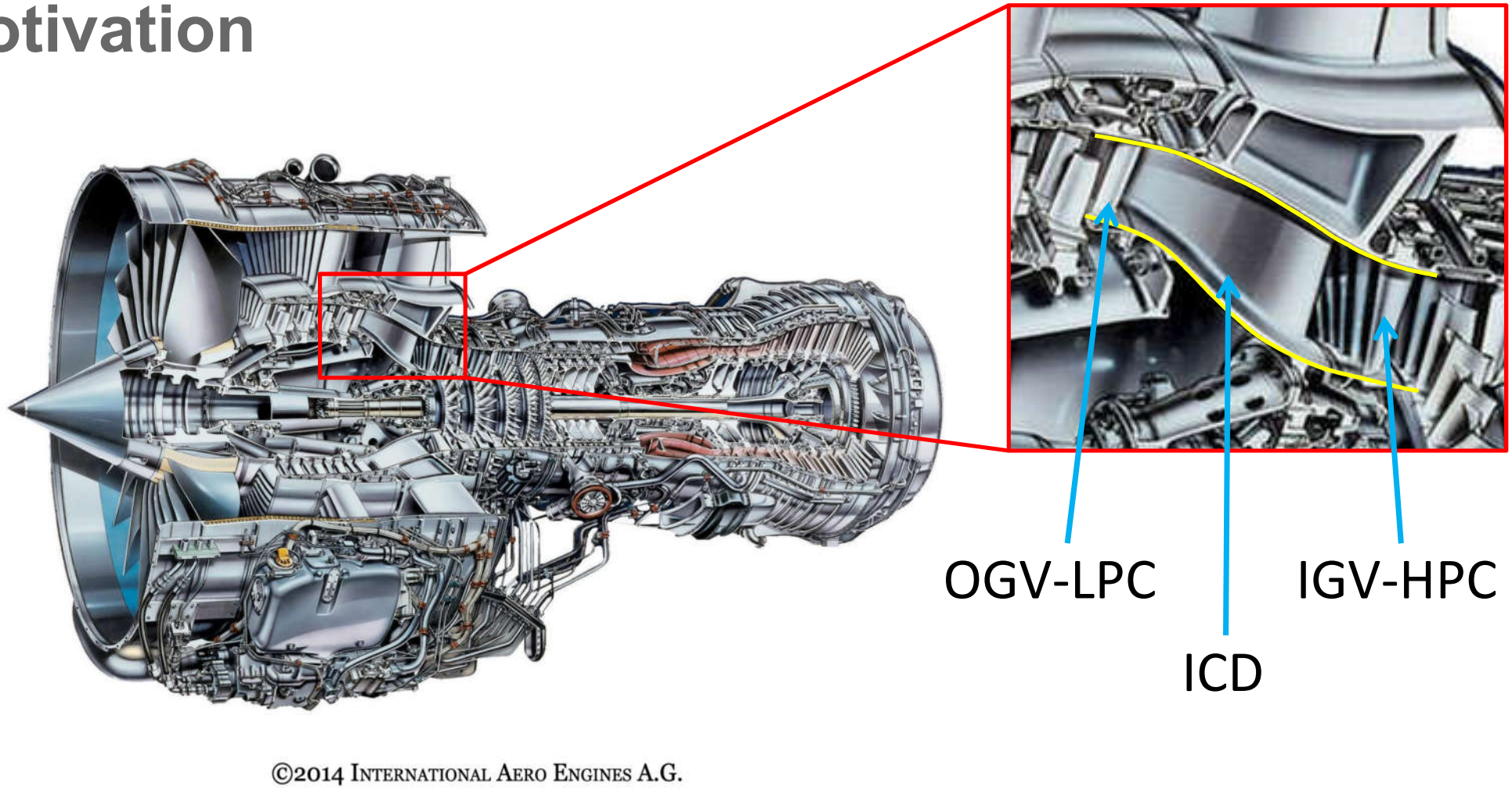
2nd Symposium on Turbomachinery Test Facilities

DLR - Institut of Propulsion Technology
Dept. Fan & Compressor
Aaron Kasper M.Sc.

- Motivation
- Testbed Description
- Techniques of Measurements
- Results
- Summary & Outlook

Motivation

Motivation



Motivation

Axial length reduction of ICD

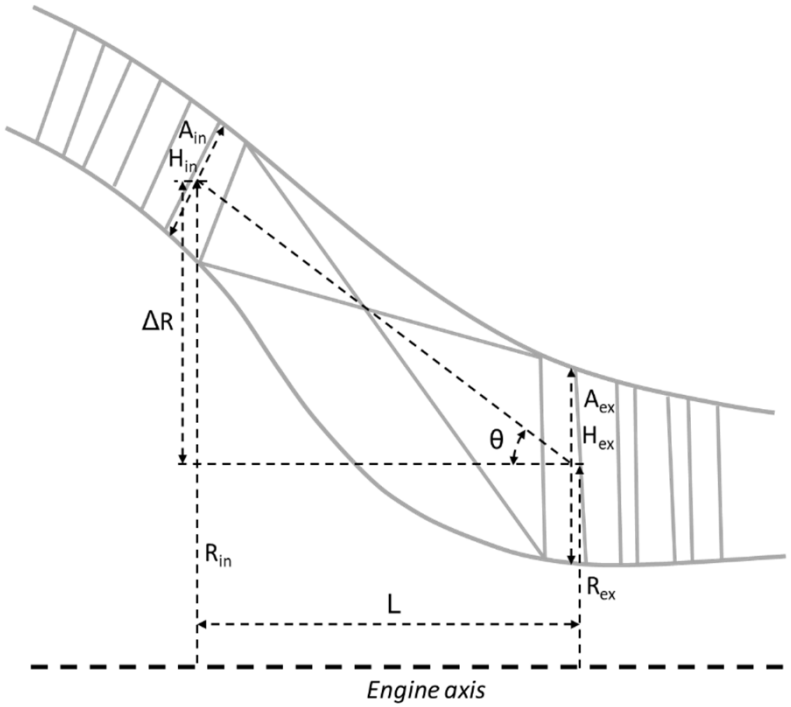
→ Axial length reduction of entire engine

→ Lower engine weight

→ Reduction of SFC

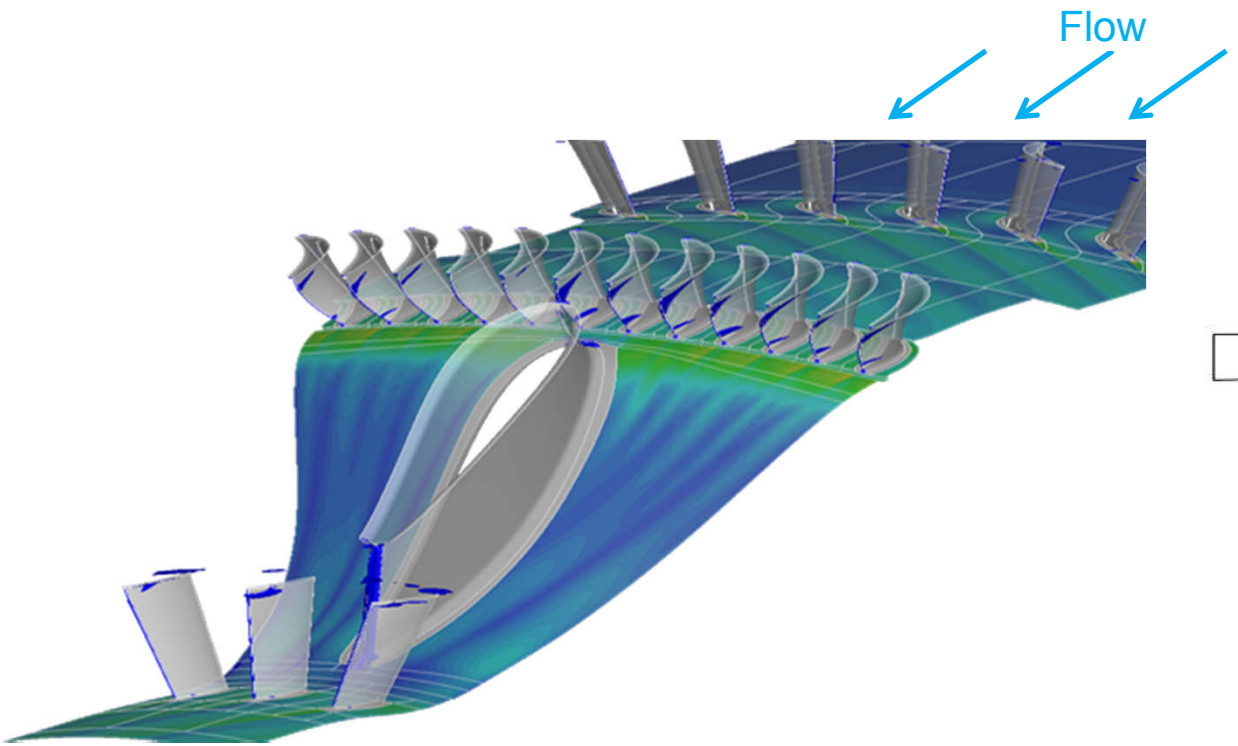
Constant or improved aerodynamic performance of ICD

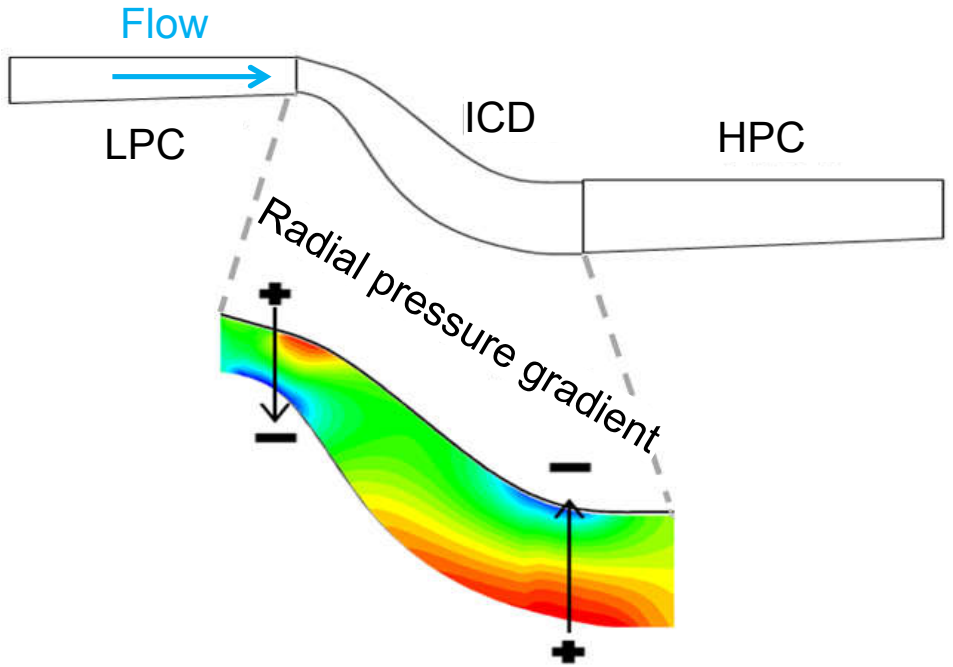
Motivation



Convent. Design	Baseline
Build 1.0	Optimized design approach Axial length reduction
Build 1.1	Aggressive design, predicted separation

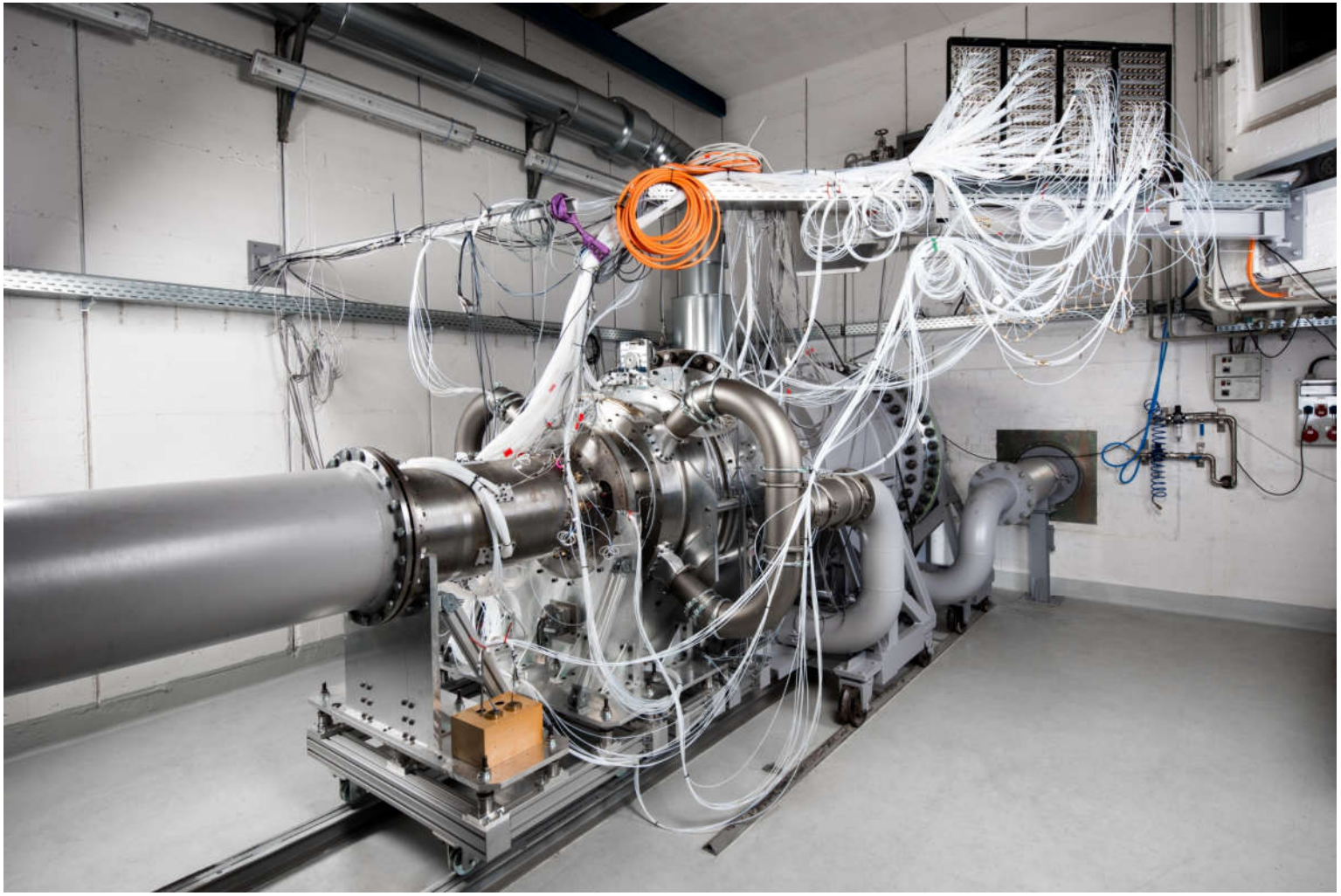
Motivation



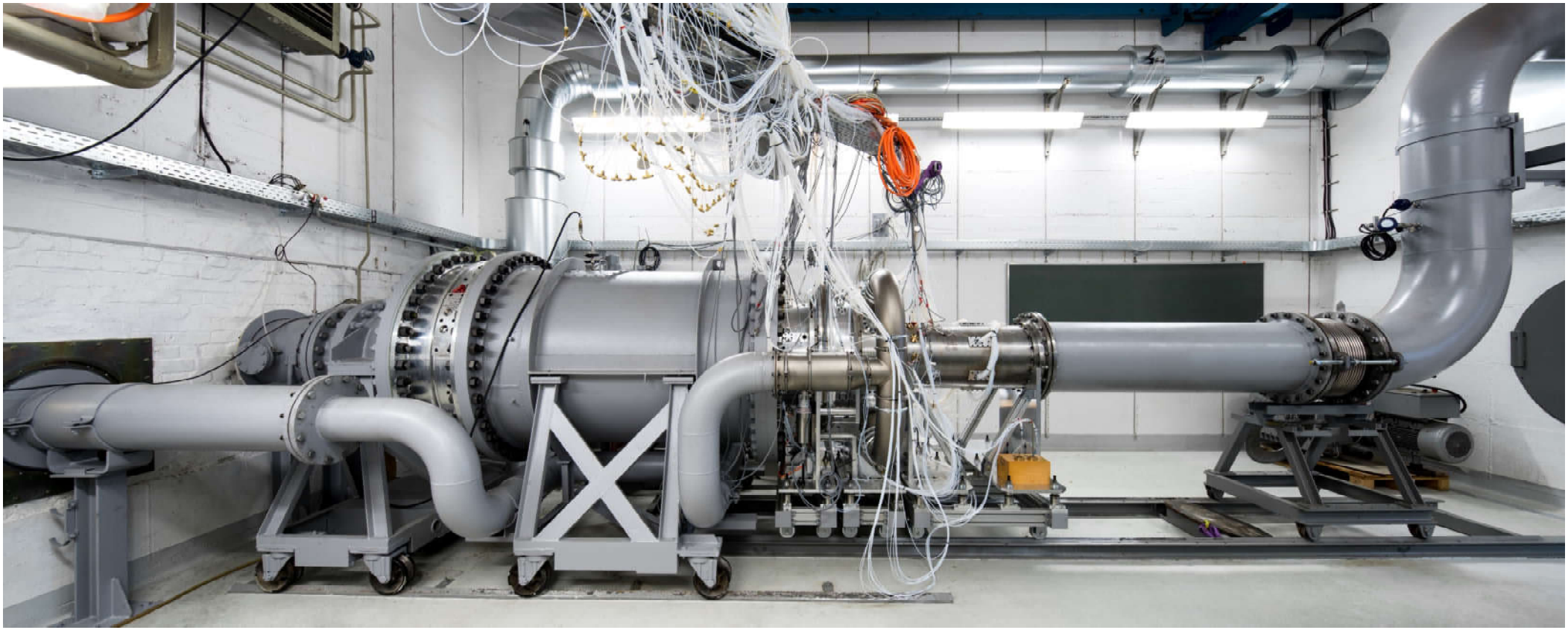


- Motivation
- Testbed Description
- Techniques of Measurements
- Results
- Summary & Outlook

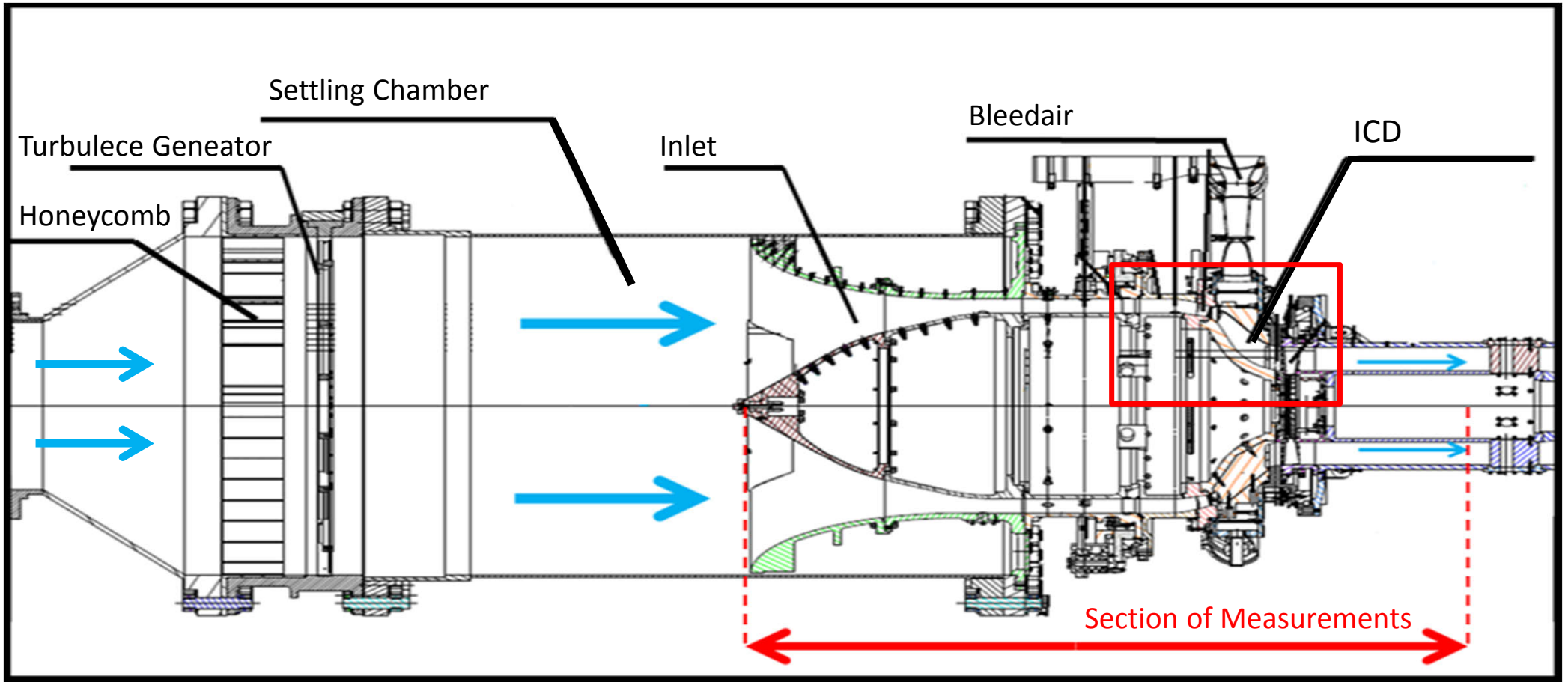
Testbed



Testbed Description

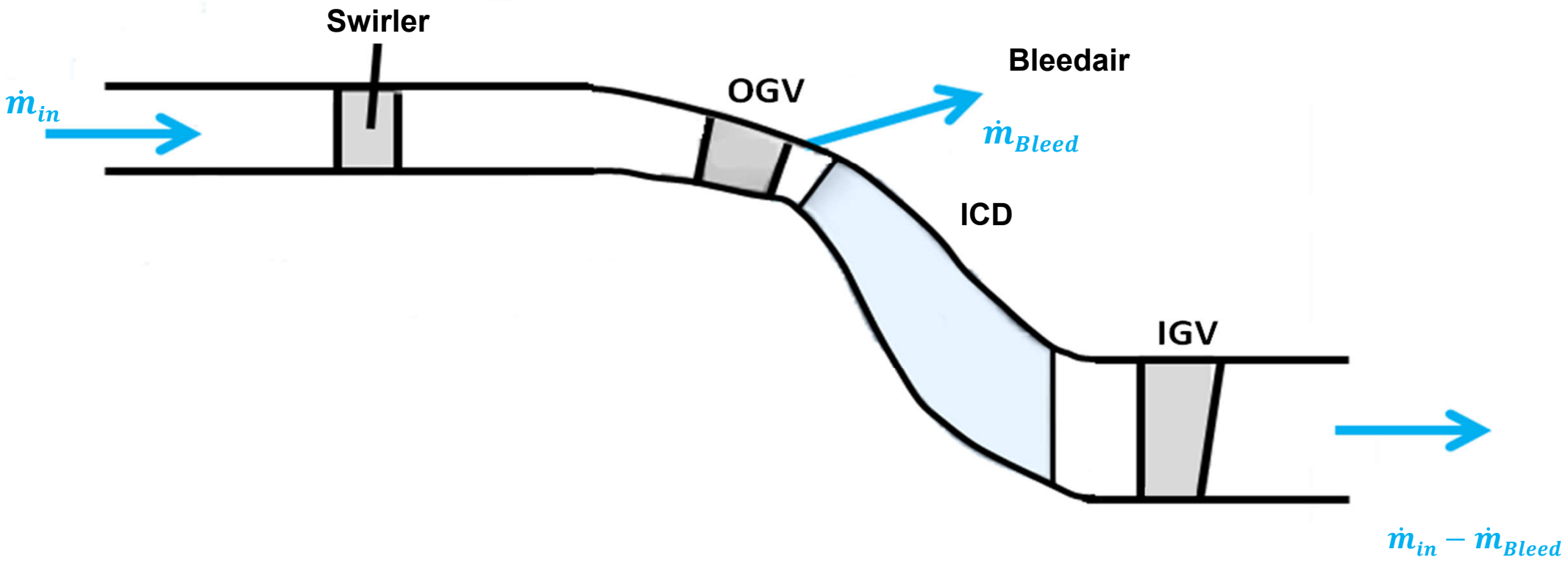


Testbed Description



Testbed Description

Section of measurements



Testbed Description

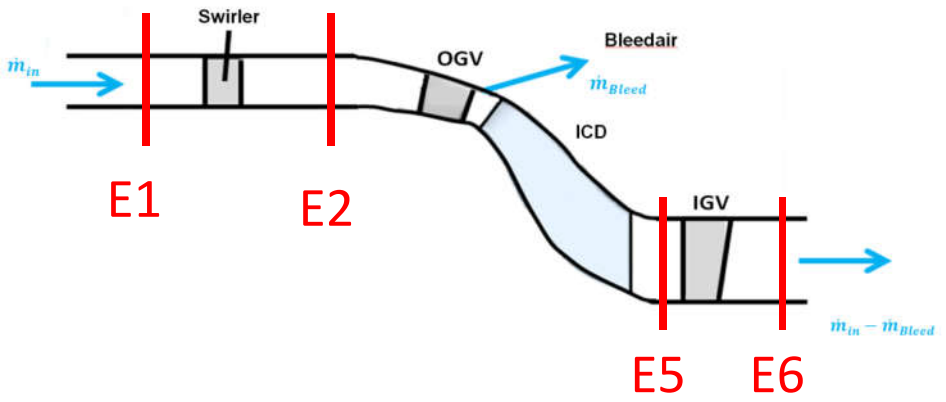
Performance specifications

Task	Range	Unit
Mach number	0.1 – 0.4	
Reynolds number	800,000 - 5,500,000	
Pressure level	60 - 250	kPa.a
Mass flow	0 - 30	kg/s
Bleed flow	0 - 6	kg/s
Humidity/dryer	~ 15	%
Swirler	± 20	deg
IGV	-60 +15	deg

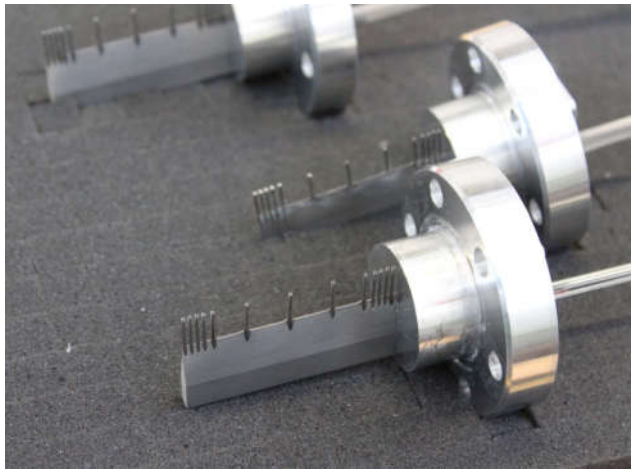
- Motivation
- Testbed Description
- Techniques of Measurements
- Results
- Summary & Outlook

Techniques of Measurements

Boundary Layer Rakes
Inlet & outlet condition

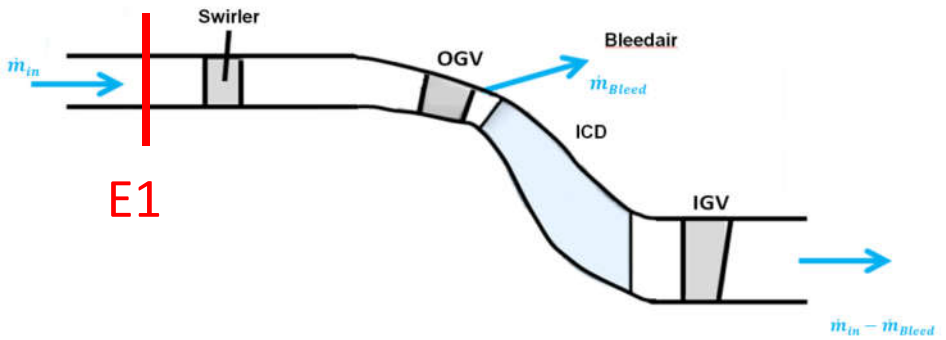


Number of rakes	
3	Inlet (E1)
1	Aft swirler (E2)
1	Aft ICD(E5)
4	Outlet (E6)
10	Total



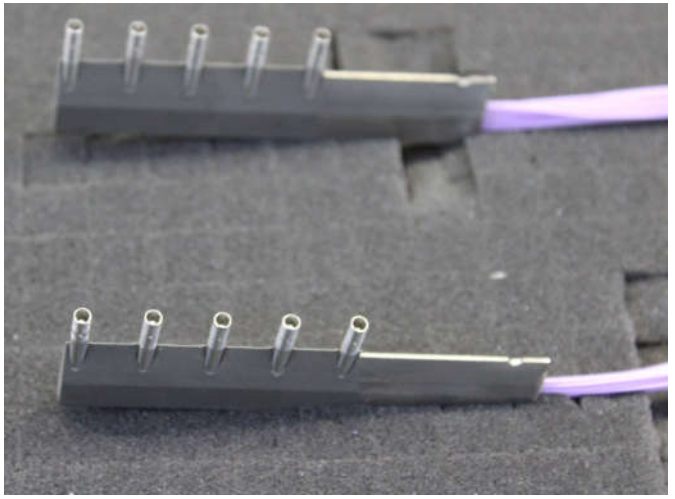
Techniques of Measurements

Temperature Rakes
Inlet condition



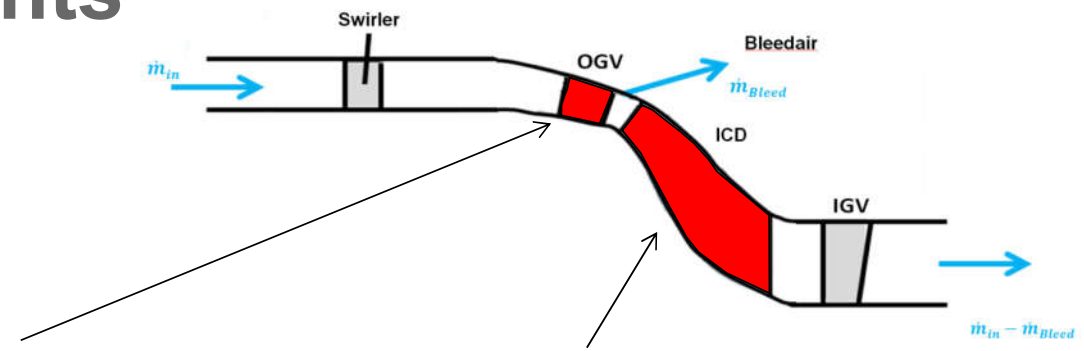
Number of rakes

3 Inlet (E1)

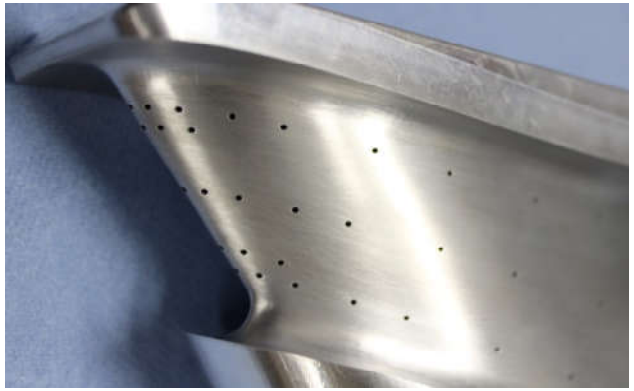


Techniques of Measurements

Static Pressure Tap
Flow behavior



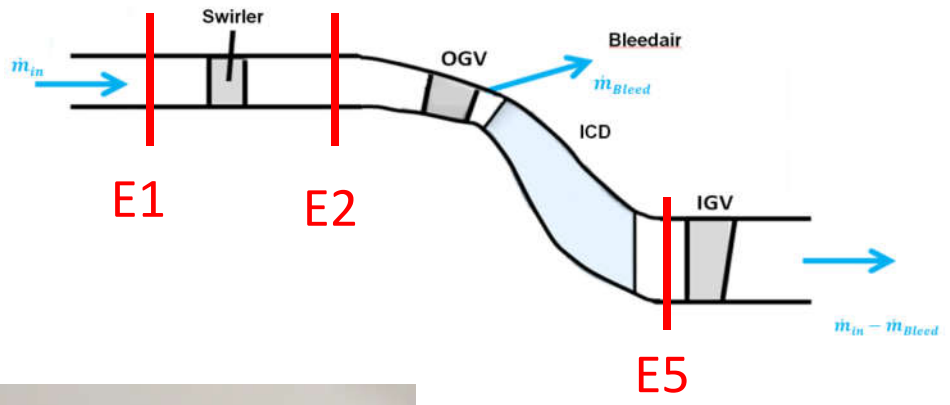
Number of Tap	
17	OGV
135	Hub & Casing
102	Strut
61	Others
316	Total



Manufactured by DLR Shop

Techniques of Measurements

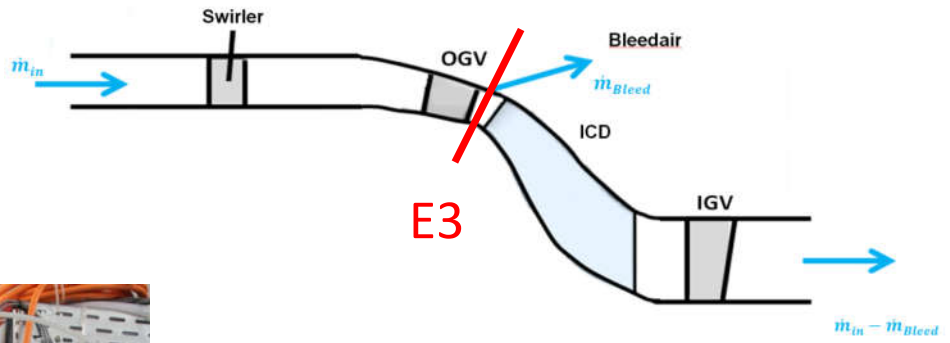
Hotwire measurements
Turbulence level, velocity



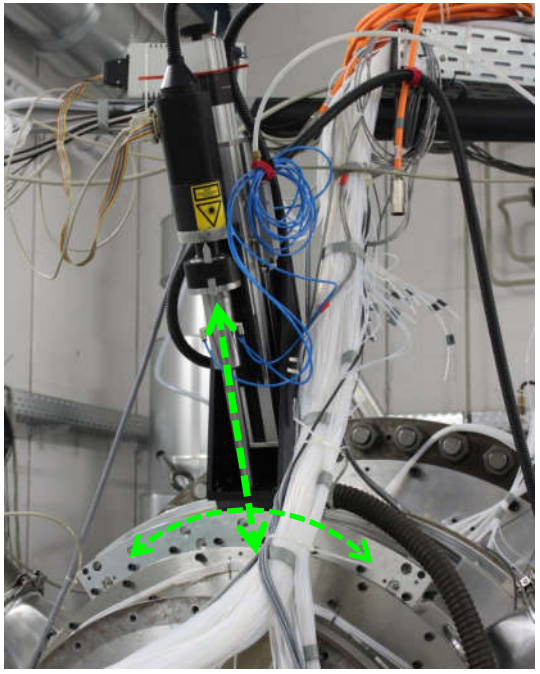
Number of locations	
2	Inlet (E1)
2	Aft swirler (E2)
2	Aft ICD (E5)
6	Total

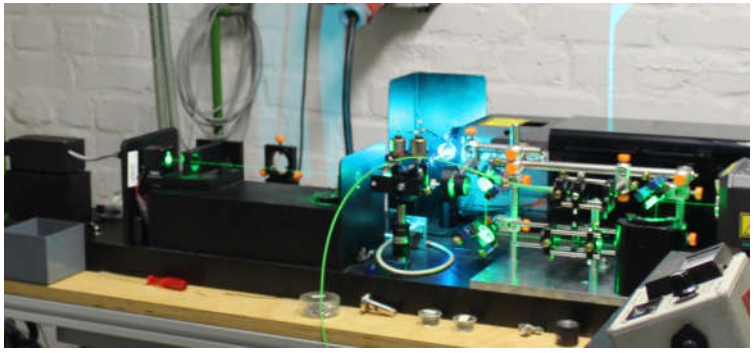
Techniques of Measurements

Laser2Fokus
Velocity, angle



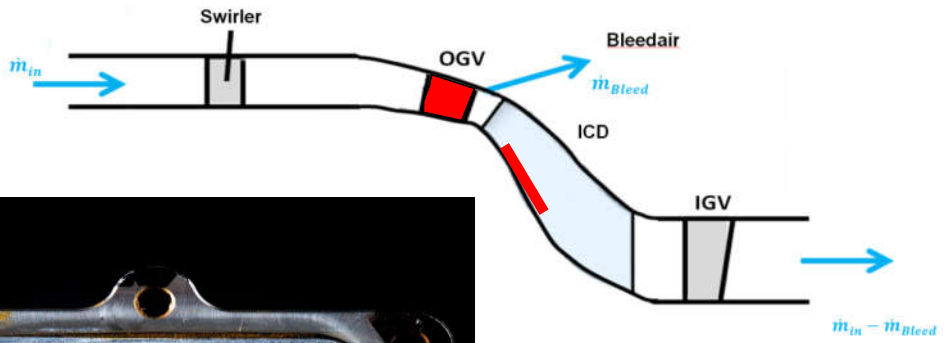
Accuracy	
0.25°	Circumferential (Range: θ = 30°)
0.1mm	Radial (Range: r(h)= 99%- 5%)
410	Measurement points

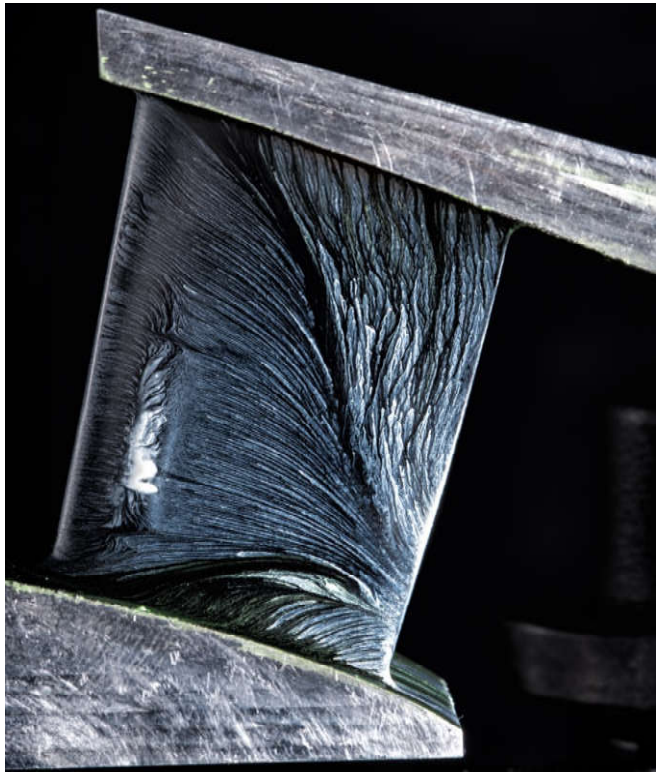




Techniques of Measurements

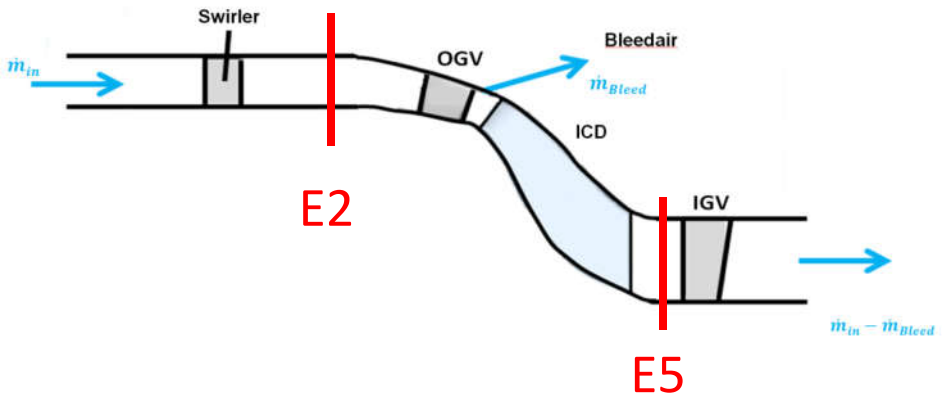
Oilstreak Pattern



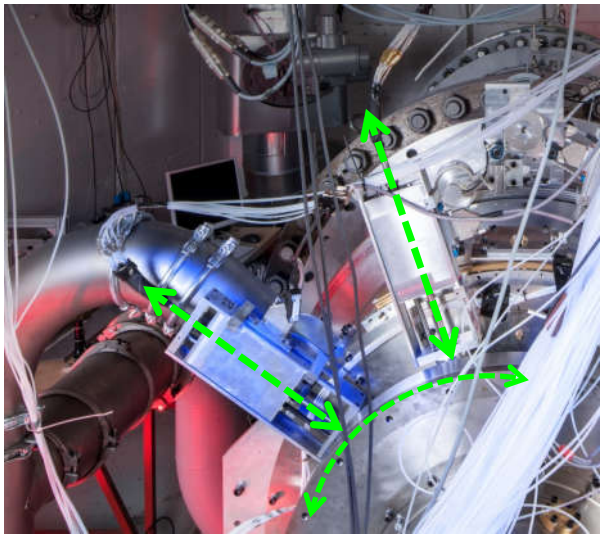


Techniques of Measurements

3 and 5 Hole Probes
Angle, Ma, Pt



Accuracy	
0.25°	Circumferential (Range: θ = 45°)
0.1mm	Radial (Range: r(h)= 98%- 4%)
468	Measurement points



Techniques of Measurements

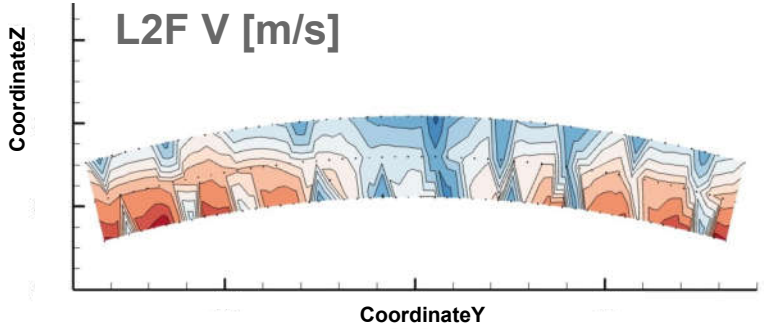
Data Acquisition

Task	Equipment	Ch.
P_s P_t	DMT PSI Moduls	464
P_{ref}	Mensor CPG2500	1
P_{baro}	Mensor CPR2550	1
hum	Vaisala HMT330	1
T_t	Delphin/Pt100	24
P_{inst}	Dewetron/ Kulite	8
Data	LabView	

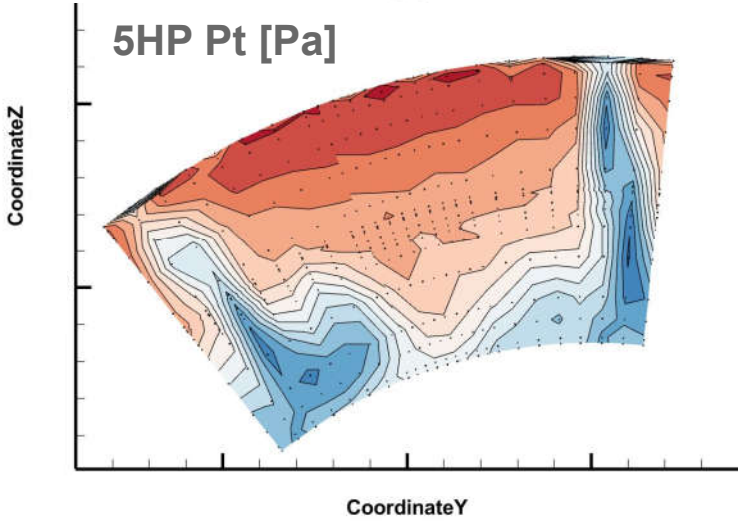
- Motivation
- Testbed
- Techniques of Measurements
- Results
- Summary & Outlook

Results

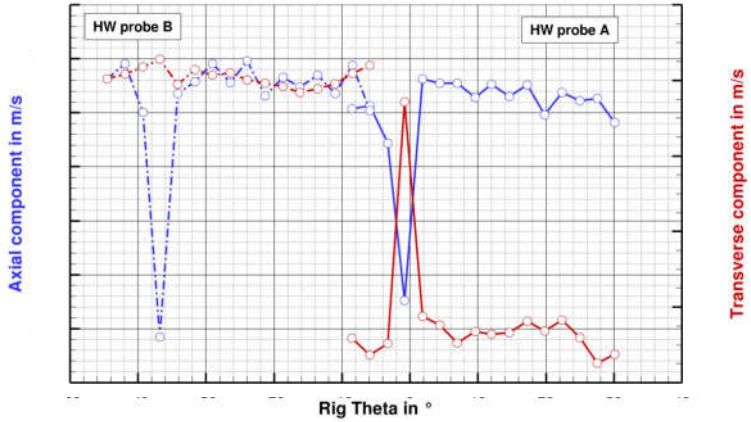
L2F V [m/s]



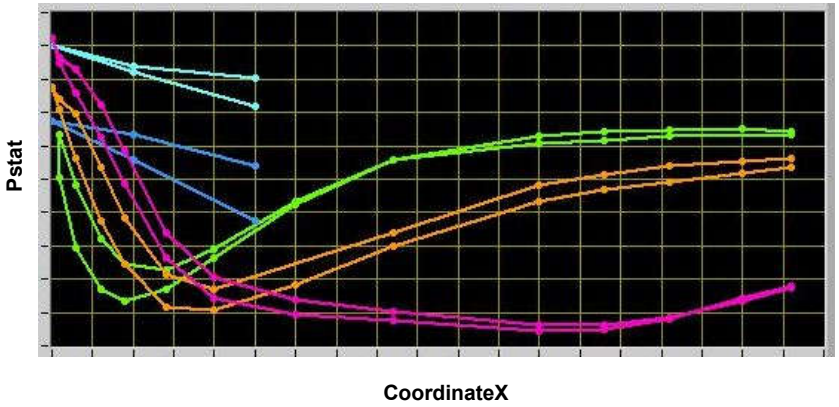
5HP Pt [Pa]



Hotwire V [m/s]



Static Pressure [Pa]



- Motivation
- Prüfstand & Messstrecke
- Techniques of Measurements
- Results
- Summary & Outlook

Summary & Outlook

Summary

- 78 test days
- High instrumentation leads to very accurate results
- Deep understanding of flow in ICD
- Measurements and previous CFD are comparable
- Axial length reduction is successful
- No separation in critical operating points

Outlook

- Further profound analysis of data (today)
- PIV measurements on Build 1.1 (summer 2019)
- Setup of Build 1.2 with endwall contouring (tbd)
- Setup of 2Spool Rig (2021)

Thank you for your attention!